Abscisic acid analogues for enhanced stress tolerance and size control of tomato seedlings

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Abstract

Transplanting shock is a common problem during establishment of horticultural crops like vegetables and ornamental bedding plants. The marketing period of nursery raised seedlings is limited due to the loss of aesthetic quality associated with undesirable growth and accelerated moisture loss during storage and handling. Two synthetic analogues (PBI 365 and PBI 429) of the plant hormone abscisic acid (S. Abrams PBI/NRC) were evaluated in a number of greenhouses and field trials at the University of Saskatchewan, for their potential to alter the stress tolerance and growth of horticultural crops. Pre-planting application of analogues, at 10^{-4} M, enhanced the tomato transplants survival under moisture stress in field conditions. Under greenhouse conditions, the ABA analogues slowed the moisture use and growth of seedlings without deteriorating the visual quality. Thus, ABA analogues could be used in horticultural crops for enhanced stand establishment as well as to hold seedlings at a particular stage thereby allowing their storage and extending the marketing period.

Introduction

Horticultural crops are highly sensitive to environmental stresses such as extremes of temperature and moisture particularly during transplanting and early establishment. Frequent watering requirements and loss of aesthetic quality of plants associated with undesirable growth, at peak marketable stage, are the common problems of nursery plants production and marketing.

The plant hormone abscisic acid (ABA) regulates diverse aspects of plant growth including water use and adaptive responses to environmental stresses. ABA regulates transpirational water use by reducing stomatal conductance (Davies and Jones, 1991). ABA-induced stomatal closure retards gaseous exchange and photosynthesis - this slows plant growth (Kriedemann *et al.*, 1972). Levels of ABA in plants can be altered through exogenous application (Abrams, 1999). Exogenously applied ABA is very short lived due to poor uptake and rapid turn over in the plant systems (Abrams *et al.*, 1997). Synthetic analogues of ABA have been developed through slight alteration in the ABA structure, which are metabolized more slowly than ABA, resulting in longer lasting and more effective biological activity (Abrams *et al*., 1997).

Two synthetic analogues of ABA, PBI 365 and PBI 429, were evaluated for their potential to alter the stress tolerance and growth of horticultural crops. The greenhouse study reported in this

paper evaluated the ABA analogues as holding agents while field trials evaluated the potential to use ABA analogues to protect tomato seedlings from the stresses encountered at transplanting.

Evaluation of ABA Analogues as Holding Agents for Tomato Seedlings

Materials and Methods

Marketable sized tomato (*Lycopersicon esculentum* cv. Manitoba) seedlings were treated with different concentrations (10^{-5} M, 5 X 10^{-5} M and 10^{-4} M) of 8' methylene (PBI 365) and 8' acetylene (PBI 429) solutions in acetone as root dips. A solution containing water and 1% acetone was used as control treatment. The treatments were arranged in a Randomized Complete Block Design on a greenhouse bench with four replicates per treatment and six plants per replicate in a six-cells pack. The plants were watered once daily and the amount of daily water use by the seedlings was determined for the next ten days. At the termination of the trial, plant height, the number of leaves per plant and shoot fresh weights were measured. Data were analyzed in SAS (GLM) program and all statistical tests were carried out at P=0.05. Orthogonal contrasts and LSD tests were used for comparison of treatment effects.

Results and Discussion

ABA analogues treatments significantly reduced plant moisture use (Figure 1) and slowed total plant growth (Figure 2). The extent of the reduction in daily moisture use and overall growth of the tomato plants varied with type of analogue and concentration of the analogue solution (Figures 1& 2). The 10^{-4} M concentration was most effective at reducing plant moisture use and slowing growth.

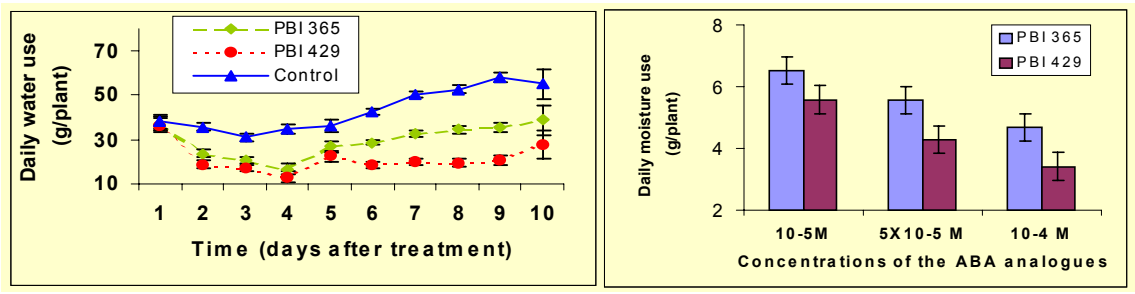

Figure 1: Effects of ABA analogues on daily moisture use of tomato seedlings

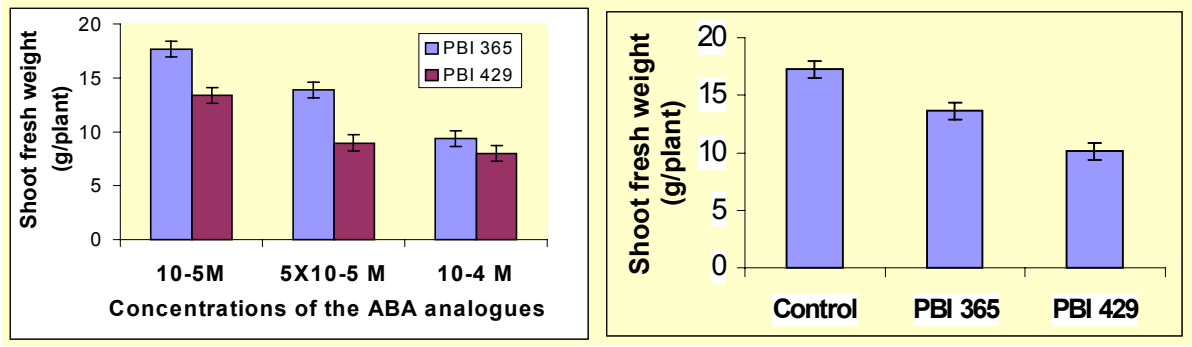

Figure 2: Effects of ABA analogues on shoot fresh weights of tomato seedlings

Watering is one of the major maintenance costs incurred in their production, handling, transportation and marketing of nursery plants. Nursery growers can potentially utilise the ABA analogues to reduce moisture loss - resulting in lowered production costs and reduced risk of moisture stress. Using ABA analogues to slow plant growth allows the growers to produce small compact plants as well as to "hold" the crop at the peak marketable stage, thereby ensuring efficient handling, transportation and display for local and distant markets.

Evaluation of ABA Analogues as Pre-transplanting Treatments for Tomato Seedlings

Materials and methods

Four weeks old tomato (*Lycopersicon esculentum* cv. Manitoba) seedlings were treated with 8' methylene ABA (PBI 365) and 8' acetylene ABA (PBI 429) solutions (10^{-4}M) either as a root dip or as a foliar spray two days before transplanting into plots at the Plant Sciences Department Horticulture Field Research Station in Saskatoon. Plants watered with 1% acetone solution served as the controls. Treatments were arranged in a Randomized Complete Block Design with four replicates per treatment and eight plants per replicate.

Visual observations on the severity of wilting were conducted daily. Leaf temperatures and leaf relative water content were recorded a day after transplanting. The trial was terminated four weeks after transplanting when the treatment effects on transplant survival and subsequent growth were distinct. At the termination of the trial, the number of plants survived, plant height, shoot fresh weight and dry weight per plant were measured. Statistical analysis procedures were similar to the greenhouse study.

Results and Discussion

The weather conditions during and following transplanting were hot and dry. The volumetric soil moisture content at transplanting was 45%. No artificial irrigation was applied following transplanting. The only moisture available to the crop came in a light rain shower (0.84-cm) on the fourth day after transplanting. The average air temperature on the day of transplanting was 20.5 ^{0}C (min 9.4 ^{0}C and maximum 31.1^{0}C). Similarly, the average soil temperature was 21.16 ^{0}C

(min. 12.9^{0}C and maximum 30.7 ^{0}C). The average air temperature for the first week of transplanting ranged from 20.9 ^{0}C to 7.3^{0}C while the average soil temperature ranged from 12.5 ^{0}C to 33.4 ^{0}C.

The control plants exhibited severe transplanting shock within a day after transplanting. The ABA analogues reduced transplanting stress as indicated by reduced wilting, lower mean temperature differential between the leaf and the air, and the higher leaf relative water content of the tomato transplants (Figure 3). PBI 429 seems to have a greater effect on transplant performance than PBI 365 but it also retarded subsequent growth of the transplants (Figure 4). Root dip treatments were more effective than foliar treatments (Figure 4).

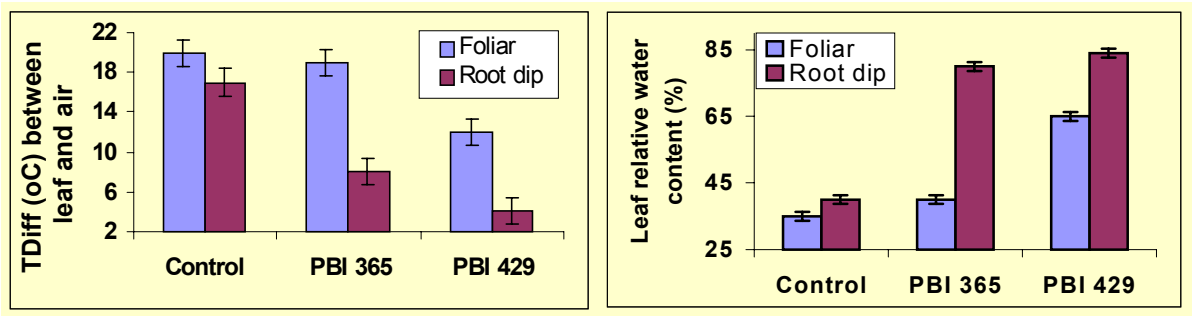

Figure 3: **Effects of ABA analogues on moisture stress tolerance of tomato transplants**

Root dip application of PBI 365 at 10^{-4}M concentration provided excellent stress tolerance with quick re-establishment growth of the transplants. From a grower's perspective, this treatment could help ensure good stand establishment without compromising on subsequent growth and yields.

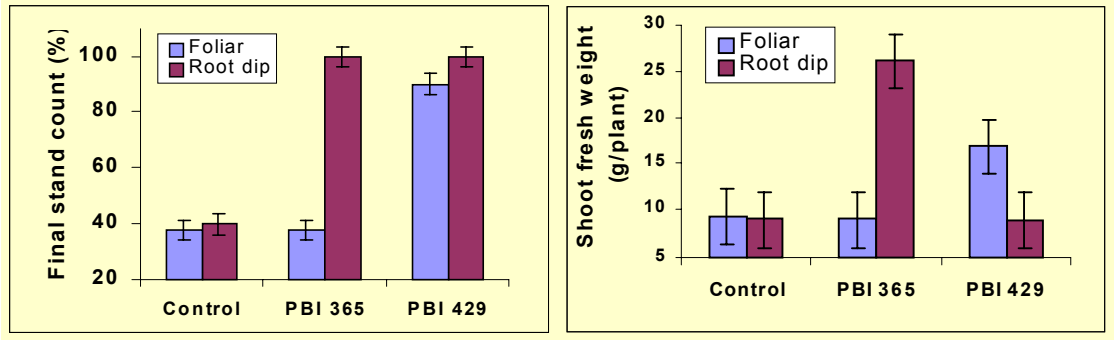

Figure 4: Influence of ABA analogues on survival and plant growth of tomato transplants

Conclusion

These studies suggested that ABA analogues could be potentially utilized in nursery grown horticultural crops to reduce moisture use and control plant growth. These treatments would

prevent loss of aesthetic quality associated with the handling, shipment and display at retail stores. ABA analogues can also be used as the pre-planting treatment to prevent transplanting shock due to heat, wind and moisture stresses in the field. Before the ABA analogues can be recommended for commercial scale use, they must be evaluated in different crops to insure against analogue dependent or crop specific negative effects.

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